PATENT SPECIFICATION (11) 1 552 350

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(21) Application No. 40088/76 (22) Filed 27th September 1976

(31) Convention Application No. 7530654 (32) Filed 7th Oct 1975 in

(33) France (FR)

(44) Complete Specification Published 12th September 1979

(51) INT. CL.[2] F04B 1/20 //
F03C 1/22
F04B 1/30 21/02

(52) Index at Acceptance
F1A 11 14D1 15E 1A1A 1B2 1B8B 3G4A
3X12 4L 4S5A 4V 6

(19)

(54) IMPROVEMENTS IN OR RELATING TO AXIAL PISTON HYDRAULIC MACHINES

(71) We, REGIE NATIONALE DES USINES RENAULT, a French Body Corporate of 8/10 Avenue Emile Zola, BOULOGNE-BILLANCOURT, Hauts de Seine, FRANCE, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:-

This invention relates in general to axial-piston hydraulic machines of which the multifarious applications as hydraulic pumps or motors are well known. It relates more particularly to the development of a hydraulic machine of the axial piston type wherein the pistons are slidably mounted in parallel cylinders consisting of bores formed in a barrel-like member, said bores opening along a circular path concentric with the axis of rotation of said barrel and registering with a distribution plate in which high- and low-pressure ports are formed for the hydraulic fluid, said barrel being rotatably mounted in relation to said distribution plate of which the face opposite the barrel-engaging sliding face has an arcuate configuration and co-acts with a corresponding arcute face of the machine case, said distribution plate being movable while in engagement with said corresponding arcuate face for varying the barrel inclination in said case, the arcuate face of said case comprising low- and high-pressure fluid passage orifices connected to elongated orifices formed in said distribution plate which communicate through internal passages with the aforesaid ports, said elongated orifices being adapted, in all angular positions of said plate, to cover the high- and low-pressure orifices of said case.

In a known practical embodiment of machines of this character the cross-section or surface area of at least one high-pressure elongated oricie of said distribution plate is reduced in comparison with that of the smallest number of barrel cylinders likely to operate simultaneously under high-pressure condition, so that the distribution plate is urged by the high pressue fluid against the arcuate face of said case.

In fact, since machines of this type comprise as a rule an odd number of pistons, mostly seven, there is alternatively a number differing by one unit of pistons operating simultaneously under high pressure (alternatively 3 or 4 in the case of a seven-piston machine). Although it would be desirable that the contact pressure exerted by the distribution plate against the arcuate face of the case be as low as possible, this contact pressure must be calculated as a function of the minimum number of pistons likely to operate simultaneously under pressure, so that any clearances be constantly taken up in the same direction. This means that the contact pressure varies cyclically by reason of at least the thrust of a piston in a cylinder under pressure, which is excessive from the point of view of mechanical strength and wear and tear. Moreover, the limitation thus imposed to the surface area of said elongated orifices leads to limit likewise the corresponding cross-sectional passage areas for the fluid, thus causing a loss of efficiency due to a loss of pressure, which is particularly detrimental at high operation speeds.

If the cross-sectional area of the elongated orifices of the distribution plate exceeds the surface area of the plurality of cylinders likely to operate simultaneously under pressure, this is practically inconsistent

with the conventional structure of pumps of this type.

It is the primary object of the present invention to provide a hydraulic machine of the axial piston type which is capable of meeting satisfactorily this last-mentioned requirement by eliminating the above-described inconveniences.

For this purpose, in an axial-piston hydraulic machine wherein the pistons are disposed in parallel relationship within a rotary barrel comprising the piston receiving cylinders communicating with orifices opening on a circular path concentric to the barrel axis and registering with a distribution plate in sliding contact with a case comprising corresponding high-pressure and low-pressure fluid passage ports, said barrel being rotatably mounted said distribution plate, a first face of said distribution plate which is opposite the barrel-engaging face being arcuate and adapted to co-act with a first corresponding arcuate face of the case of the machine which comprises high-pressure and low-pressure fluid passage orifices, said last-mentioned orifices registering with elongated orifices formed in said distribution plate of which the cross-sectional surface is greater than the surface of the plurality of cylinders likely to operate simultaneously under pressure, this invention being characerised in that said distribution plate comprises and arcuate face directed towards said barrel but bearing against a second arcuate face of said case.

Preferably, hydrostatic bearings are formed between the aforesaid arcuate face directed towards said barrel and said second arcuate face of said case, said bearings being advantageously of the self-regulating or self-adjusting type.

Other features and advantages of this invention will appear as the following description proceeds with reference to the accompanying drawing illustrating a typical form of embodiment of a hydraulic machine constructed according to the teachings of this invention. In the drawing:

Figure 1 is an axial section of the machine, taken along the line I-I of Figure 2;

Figure 2 is a section taken along the line II-II of Figure 1;

Figure 3 is a view taken in the direction of the arrow III of Figure 4, showing the distribution plate;

Figure 4 is a side elevational view of the distribution plate, as seen in the direction of the arrow IV of Figure 3;

Figure 5 is a section taken along the line V-V of Figure 4, and

Figure 6 is a view similar to Figure 5 but showing a modified form of embodiment.

To facilitate the description, it will be assumed that the machine illustrated in the drawing is a pump, but it will readily occur to those conversant with the art that this machine may also be operated as amotor.

The pump illustrated comprises a case having a central body 1 closed at one end by a plate or flange 2; a pump driving shaft extends through the center of this plate 2; the opposite end of said body 1 is closed by a cover 4 comprising a (low pressure) inlet port 5 and a (high pressure) outlet port 6 for the working fluid. This shaft 3 is adapted rotatably to drive through splines 7 an impeller plate 8 mounted by means of a roller bearing 9 in said body 1. The impeller plate 8 is formed with part-spherical recesses engaged by the corresponding spherical "big–ends" of connection rods 10 having their "small ends" coupled to corresponding pistons 11 slidably mounted in parallel axial cylinders 12 consisting of bores formed in a barrel 13, these cylinders being disposed at spaced intervals along the generatrices of a cylinder and being for example seven in number.

Another function of shaft 3 is to rotatably drive the barrel 13 through a homokinetic transmission comprising a connecting-rod 14 provided with cross-pins 14*a*, 14*b* engaging internal splines of shaft 3 and barrel 13 and coupled through ball-and-socket means therewith. One of the crosspins mounting said connecting-rod engages a bearing member 15 engaging in turn a spring 16 housed within the shaft 3 in order to compensate the variations occurring in the position of said connecting-rod when the barrel assumes a different inclination in relation to the impeller plate 8, as will be explained presently.

The barrel 13 is rotatably mounted by means of a bearing 17 on a stub shaft extension 18 of a fluid distribution plate 19 interposed between said barrel 13 and the case cover 4. This distribution plate 19 has a face 20 registering with the adjacent face of the barrel and having formed therein a low-pressure arcuate port 21 and a high-pressure arcuate port 22 for the pumped fluid, said ports being interposed in the path of the cylinder bottom orifices 23. The distribution plate 19 further comprises a face 24 opposite said face 20 which is also arcuate and co-acts with an internal and similar arcuate face 25 of cover 4, these arcuate faces consisting of part-cylindrical surfaces centered at 26, i.e. centrally of the impeller plate 8 and in the plane comprising the axes of the ball-and-socket joints interconnecting the connecting-rods 10 and the impeller plate 8, whereby the distribution plate 19 can be moved angularly about the center axis 26 for varying as required the inclination of said barrel 13 in the case, and consequently the cubic capacity of the machine. In this example, this variation is obtained by means of an arm 27 fulcrumed to a pivot pin 28 carried by plate

19 (see Figure 1). This plate 19 is furthermore guided laterally in the case body 1 by having its side faces in sliding engagement with lateral guideways 29, but obviously this guiding action may also be obtained between the plate 19 and the cover 4, for example by means of a key and groove arrangement. The top face 24 of distribution plate 19 has a pair of elongated orifices 30, 31 formed therein which communicate via internal passages 32, 33 formed in said plate 19 with the inlet and outlet ports 21, 22, respectively, for the pumped fluid. These elongated orifices 30, 31 are adapted to cover the inlet and outlet orifices 5 and 6, respectively, terminating at the arcuate face 25 of said cover 4, irrespective of the inclination likely to be assumed by the plate 19 and barrel 13 together. Adequate seals 34 surround the elongated orifices 30, 31 to prevent any leakage therearound; if desired, the seals disclosed in the Applicants' British Patent No. 1.353.642 may be used for this purpose.

The cross-sectional area of at least one high-pressure elongated orifice 31, and in this example also that of the elongated orifice 30, at least in the case of a reversible machine, is selected to be greater than the surface area of all the cylinders likely to operate simultaneuosly under high-pressure condition, so that the thrust exerted by the pumped or forced fluid will tent to constantly urge the distribution plate against the barrel, i.e. with a force in excess to that resulting from the action exerted by the fluid pressure in the cylinders, even if at the time four out of the seven cylinders are operating under high pressure condition. The difference between the high-pressure fluid thrust exerted through the corresponding elongated orifice against the distribution plate, on the one hand, and the opposite thrust of the high-pressure fluid which is exerted within the corresponding cylinders, on the other hand, will thus be predominant in the direction from the distribution plate to the barrel, and is compensated in this case by means of a hydrostatic bearing provided between the distribution plate and the case, along registering arcuate faces 35, 36, homologues of the aforesaid arcuate faces 24, 25, said arcuate faces 35, 36 also consisting therefore of cylindrical surfaces centered to the axis 26 These bearings comprise elongated cavities, in this example four in number, namely two on either side of the plate, these cavities being designated by the reference numerals 37, 38, 39, 40 and formed in the arcuate surfaces 35 of the plate from which these cavities are supplied with high-pressure fluid.

Figure 5 illustrates a typical form of embodiment of said cavities corresponding to a pump or motor construction wherein the port 22 and the relevant passage 33 are in all cases high-pressure fluid passages, this passage 33 being in this example connected via internal bores to the four cavities 37-40 These internal conduits comprise a pair of blind secant bores 41-42 stopped after drilling them in said plate 19, one bore 41 passing through the aforesaid passage 33; four stopped bores 43, 44, 45, 46 opening into the other bore 42, and four small bores 47, 48, 49 and 50 connecting said bores 43-46 to cavities 37, 38, 39 and 40. Preferably, these bearings are of the self-regulating or self-adjusting type in a manner known per se, by supplying said cavities by means of narrow orifices adapted to cause a loss of pressure and consisting in the example of helical grooves formed on the outer periphery of cylindrical plugs 51 inserted into the bores 43 to 46, and also by giving to said cavities relatively large dimensions whereby the variations in their leakages entail substantial variations in the pressure prevailing in each cavity, whereby these bearing will constantly adapt themselves to the distribution plate thrust to be compensated. In fact, it may be reminded that this thrust to be compensated varies both in amplitude and in position as to its resultant, considering the fact that the pistons operating simultaneously under high-pressure condition are alternatively three or four in number in the machine contemplated herein.

Of course, hydrostaic bearings having cavities of smaller cross-sectional area may be used, and these cavities may be supplied directly with fluid under pressure; in this case, the thrust variatons are absorbed mechanically. Alternativley, any other bearing structure, even of mechanical construction, such as ball-bearings, may be used, provided that their size be consistent with the thrust to be coped with, which may be as high as implied notably by the choice permitted by the present invention of cross-sectional fluid passage areas directed to reduce losses of pressure and improve the efficiency of the machine.

Figure 6 illustrates as an alternative a modified form of embodiment of the cavities of the above-described hydrostatic bearings, which corresponds to the case of a pump (or motor) wherein the functions of ports 21, 22 and of the corresponding passages 32, 33 may be inverted, said last-mentioned passages 32, 33 being connected in this case to the bore 42 via a bore 41*a* in which a ball-type selector valve 52 is interposed, the ball of this valve closing automatically, under the influence of the fluid under pressure issuing from the high-pressure fluid passage 32 or 33, the communication between said bore 42 and the other low-pressure passage 33 or 32.

Although a specific form of embodiment of this invention has been described herein-

above and illustrated in the accompanying drawing, it will readily occur to those skilled in the art that various modifications and changes may be brought thereto without departing from the scope of the invention as set forth in the appended claims.

WHAT WE CLAIM IS:–

1. A hydraulic machine having axial pistons disposed in a rotary barrel comprising cylinder bores for slidably receiving said pistons, said bores communicating with orifices opening along a circular path concentric with the axis of rotation of said barrel, and registering with a distribution plate in constant sliding contact with a case, said distribution plate comprising corresponding high-pressure and low-pressure fluid passage ports, said barrel being rotatably mounted in relation to said distribution plate, a first face of said distribution plate opposite to the barrel-engaging face being arcuate and co-acting with a first arcuate face of corresponding curvature formed in the machine case, said first arcuate face of the machine case comprising high-pressure and low-pressure passage orifices registering with elongated orifices formed in said distribution plate, the surface area of said elongated orifices exceeding the total surface area of the plurality of cylinders likely to operate simultaneously under high-pressure condition, this machine being characterised in that said distribution plate further comprises an arcuate face directed towards said barrel which bears against a second arcuate face of said case.

2. Axial-piston hydraulic machine as disclosed in claim 1, characterised in that hydrostatic bearings are provided between said arcuate face directed towards said barrel and said second arcuate face of said case.

3. Axial-piston hydrallic machine as disclosed in claim 2, characterised in that said hydrostatic bearings consists on said distribution plate of cavaties supplied with hydraulic fluid under high pressure from an internal passage of said distribution plare.

4. Axial-piston hydraulic machine as disclosed in claim 2 or 3, characterised in that said hydrostatic bearings are supplied separately via narrow passages adapted to create pressure losses.

5. Axial-piston hydraulic machine substantially as described herein with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by MULTIPLEX techniques ltd., St. Mary Cray, Kent. 1979. Published at the Patent Office, 25 Southampton Buildings, London WC2 1AY, from which copies may be obtained.

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Sheet 1

Fig. 1

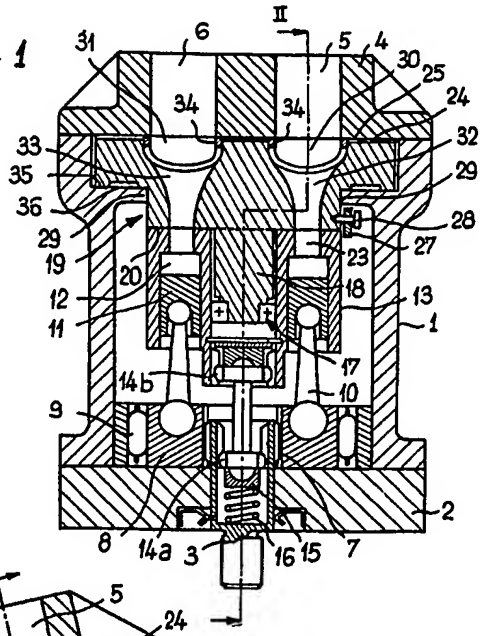
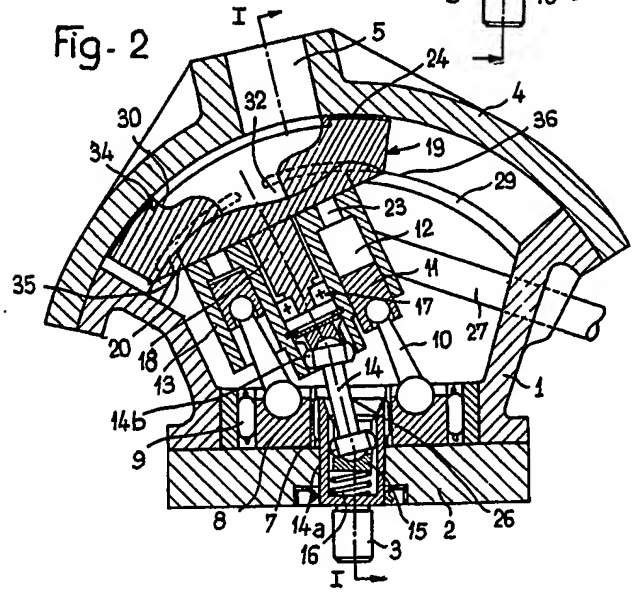


Fig. 2



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Sheet 2

Fig. 3

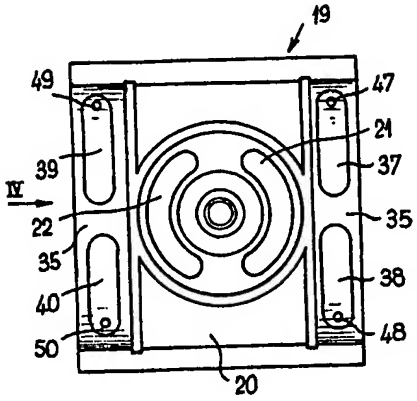
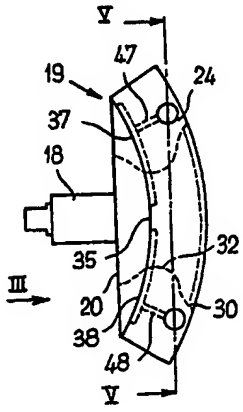


Fig. 4



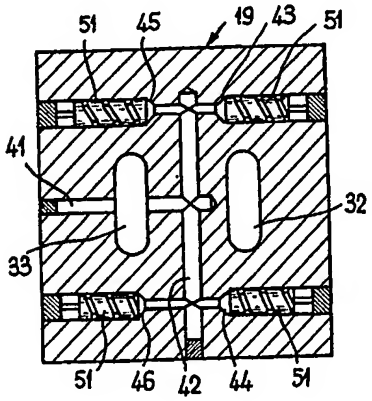


Fig. 5

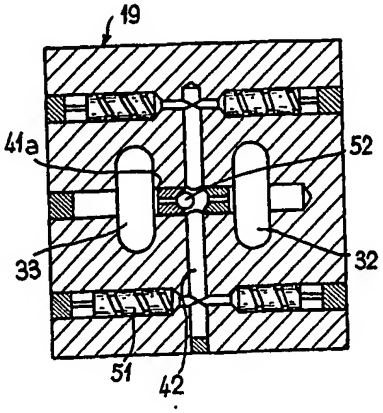


Fig. 6